Asymmetric transmission and effects of resource shocks: Case of Mongolia

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Abstract

This paper contributes to the empirical evidence on Dutch disease by studying the transmission of resource shocks in Mongolia. Asymmetric resource shock transmissions adjusted for the business cycle stage were estimated using a Markov Switching Vector Autoregression model (VAR) and data from 2000Q1 to 2019Q4. The results of these and additional estimates employing recursive and non-recursive VAR models found evidence of a positive technological spillover effect from the resource sector on the Mongolian economy. However, it is evident that the main source of economic volatility is from the mining sector.

JEL Codes: C32, E32, F43, F62

Keywords: Resource shocks, Mongolia, Markov Switching VAR, SVAR.

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I. INTRODUCTION

Macroeconomic policy is of central importance to the economic development of resource-rich countries, for which high economic volatility and Dutch disease are major concerns. Likewise, optimising macroeconomic management requires a better understanding of the transmission of resource shocks through the economy. This research studies the effects of resource sector shocks on Mongolia - a small, open, and resource-rich economy - using Markov-Switching and Structural VAR models with recursive and non-recursive identification methods.

More than 80 per cent of Mongolian exports are commodities (copper, coal, gold, crude oil and iron ore), making it a natural resource-dependent country. In addition to resource dependence, Mongolian exports are highly reliant on China as a destination. Given these two dependencies, Chinese industrial production represents a useful proxy for measuring the effects of resource sectors shocks on Mongolia.

Commodities have characteristically volatile prices (Brahmbhatt et al. 2010), which creates short-term economic volatility for commodity-dependent countries. Meanwhile, the long-term concern with commodity dependence is that it inhibits the development of other sectors – a phenomenon known as Dutch disease. Dutch disease is where high revenue from and foreign investment into the resource sector exert considerable pressure on the real exchange rate to appreciate, which may affect the competitiveness of other tradable sectors and create a more concentrated, fragile economic structure. To reduce economic volatility and manage the economy well, it is important to understand how resource shocks transmit to the domestic economy.

A leading theoretical perspective on Dutch disease, Corden and Neary (1982), analyses two main channels: factor movements and spending. The factor movement effect is that resources (labour and capital) shift to the booming commodity sector due to its higher marginal productivity. Within-country factor movements may be less relevant for developing countries since mining industries are mainly capital intensive, and inputs are mostly imported (Brahmbhatt et al. 2010, p. 4). Through the spending channel, increased capital inflow into the commodity sector boosts demand in the non-tradable sector, which raises the real exchange rate. Additionally, Frankel (2010, pp. 19-20) explains the influence of business cycle effects. The loss of competitiveness in other tradable sectors leaves the country vulnerable to trade deficits and possible balance of payments difficulties in periods of low commodity prices.

However, empirical evidence provides little support for these theoretical statements. Literature surveys from van der Ploeg (2011) and Venables (2016) show significant heterogeneity in countries' experiences. They concluded that macroeconomic effects depend on the country's economic characteristics and institutional qualities. Smith (2015) found that resource exploitation had a positive impact on long term GDP per capita in developing countries based on a quasi-experimental, treatment–control approach using data since 1950 for all possible countries. Bjørnland and Thorsrud (2016) evidenced a positive technological spillover effect from resource sector development in Australia and Norway, employing a Bayesian dynamic factor model and quarterly data (1991Q1-2012Q4 for Australia; 1996Q1-2012Q4 for Norway). Nasir et al. (2019) found that oil price shocks positively affected the GDP of Gulf Cooperation Council member countries (Bahrain, Kuwait, KSA, Oman, Qatar and UAE) using an SVAR model with Cholesky identification (oil price, GDP, trade balance and inflation) for the period 1980–2016. Most recently and relevantly, Dungey et al. (2020) studied the transmission of resource demand and supply shocks on the Australian economy using SVAR and multivariate historical decomposition based on data from 1988Q1 to 2016Q1. Even though their SVAR model returned an overall negative impact of resource shocks on GDP, they concluded it was not substantial. Their multivariate historical decomposition analysis found evidence that the economy adjusts over time such that resource shocks have positive impacts.

With respect to Mongolia, the only relevant literature comes from Doojav & Luvsannyam (2019); who describe the importance of external shocks on the Mongolian business cycle. They identified commodity prices, the Chinese economy and FDI shocks as transmission channels by estimating a Bayesian VAR model with Cholesky identification using quarterly data between 2000Q4 and 2016Q3.

This paper adopts a similar method to Dungey et.al (2020) while additionally employing a Markov-switching VAR model to identify how resource shocks influenced macroeconomic conditions in Mongolia and signs of Dutch disease. The Markov-switching VAR model enables a deeper understanding of the boom and bust cycle and provides different estimated effects depending on what stage of the cycle the economy is in. This is important because the behaviour of economic agents tends to differ depending on the economic situation and cycle.

The results suggest that Chinese Industrial production and export price shocks exhibit similar behaviour. This is because Mongolian companies have little influence over prices, so export prices change in line with demand. When the economy is booming, positive demand and price shocks produce higher spillover effects through larger increases in FDI. Shocks have a lower impact on the economy during recessions because investors are more cautious than they are during stages of positive growth. The overall accumulated impact of shocks on Mongolian GDP growth is 1.5 per cent in boom times and 0.4 per cent during downturns. The effects are even higher under additional model restrictions for some foreign variables (Chinese industrial production and export price) and monetary policy responses. Mining export changes are used to model a resource supply shock, and this delivers relatively short-lived effects. Overall positive impacts of resource shocks on output support the arguments of Bjørnland and Thorsrud (2016). The variance of output during upturns is mostly explained by foreign shocks, which account for about 60 per cent in the short-run and 80 per cent in the medium-term. In contrast, domestic variables explain about 80 per cent of short-run variance in a downturn and 60 per cent in the long-run.

This paper is organised as follows. Section II describes the empirical framework, modelling approach, variables and data; Section III discusses the estimation results including impulse response analysis of the resource sector shocks; forecast error variance decomposition and historical decomposition for Mongolian output; the final section provides a conclusion.

II. EMPIRICAL FRAMEWORK

This section first introduces the variables chosen then outlines the three types of VAR models used and model identification.

This paper is used recursive, non-recursive and Markov-Switching VAR models. Variable choices and non-recursive VAR identification mostly follow Dungey et al. (2020). However, some different variables were required due to data availability and to better suit Mongolian economic conditions. Additionally, the identification of the exchange rate is different from Dungey et al. (2020) under the non-recursive VAR. In this paper, the non-recursive VAR assumes that Mongolian monetary policy affects the exchange rate contemporaneously based on the Mongolian monetary policy rule. Lastly, Dungey et al. (2020) assumes that the Australian economy can affect international variables with lags because they have market power in commodity markets, while this paper assumes that the Mongolian economy is too small to influence Chinese industrial production or the US dollar-denominated export price index.

2.1 Variable choice and data description

To study resource transmission in the Australian economy, Dungey et al. (2020) used Chinese steel production as a proxy for resource demand shock; commodity prices for the resource supply shock; foreign output to account for non-resource sector external demand; iron ore exports, mining investment; domestic output; inflation; the cash rate and the exchange rate. In this paper's analysis of Mongolia, four foreign variables - Chinese industrial production, the export price index, mining exports and FDI - and four domestic variables - domestic output, inflation, policy interest rate and exchange rate - were used. The inclusion of these variables is explained separately below.

- **Chinese industrial production (*ip_cn*):** Considering about 90 per cent of Mongolia's total exports go to China, and the major export commodities are used in Chinese industrial production, Chinese industrial production is chosen to represent Chinese resource demand. Yearly growth in Chinese industrial production is used due to data availability.
- **Export price index (*px*):** As more than 80 per cent of total exports in Mongolia are commodities (copper, coal, gold, crude oil and iron ore), the overall export price index is used as a measure of resource prices. The index is calculated from export prices in USD.
- **Mining exports (*minex*):** Mining export values in USD are used to examine the effects of resource shocks into the resource sector in Mongolia.
- **FDI (*fdi*):** FDI in USD provides a proxy for mining investment. One of the big influences on the economy is mining investment in Mongolia, which is mainly financed from abroad and may be motivated by high demand and high prices for commodities. Because of data availability and the major share of FDI in overall mining investment, FDI provides a proxy for mining investment in Mongolia.
- **Domestic macroeconomic variables:** the choice of domestic macroeconomic variables is influenced by a need to minimise total variables because of the small sample size and the curse of dimensionality. That said, the variables need to sufficiently capture the effects of resource sector shocks on the economy and the monetary policy reaction to those shocks. Fiscal policy shocks are ultimately

aggregate demand shocks while productivity and unit labour cost shocks can emerge as inflation shocks (Dungey & Pagan 2000, p.324). Domestic output (*yd*) is GDP (in real domestic currency) and inflation (*pd*) is measured by the CPI for Ulaanbaatar city due to data availability. The Policy interest rate (*rd*) and the trade-weighted real effective exchange rate (*q*) are also included.

Data: The study employs quarterly data between 2000Q1 and 2019Q4. All variables are in log form except for the interest rate and Chinese industrial production growth rate. All variables are seasonally adjusted by the X-13ARIMA-SEATS approach. Variables are de-meaned and de-trended following Dungey et al. (2020), because of the SVAR model's analysis dynamics around the steady-state. Instead of a systemic steady-state, trends are removed from individual variables, which is ultimately consistent with the cross variable systemic steady-state (Dungey et al. 2020, p.5). The description of the variables and data sources are contained in Appendices 1 to 3.

2.2 SVAR identification and approaches

This paper analyses the resource shock transmission in Mongolia through different VAR approaches - recursive, non-recursive and Markov-Switching VAR models as explained individually below.

The lag length is chosen to be two quarters. Although the lag length selection criteria suggests seven lag, two quarters lag is chosen based on lag exclusion test and data fitting (Appendix 4). The VAR stability condition (Appendix 5) was satisfied for all models. The impulse response functions, variance decomposition and historical decomposition are used to analyse the impacts of resource shocks on the economy.

1. **Recursive (Cholesky) VAR.**

   In the VAR system, variables are ordered by X_t.

$$X_t = \left[ip_{cn_t}\ px_t\ minex_t\ fdi_t\ yd_t\ pd_t\ rd_t\ q_t\right]'$$

Because Mongolia is a small open economy, the foreign variables are ordered before the domestic variables. In order words, the domestic variables do not affect foreign variables contemporaneously. Chinese industrial production (ip_{cn_t}) is first in the model, assuming that other variables do not affect Chinese industrial production contemporaneously. While the real exchange rate is affected by all other variables in the system contemporaneously. There are no restrictions on the lagged variables.

The VAR system is

$$B_0 X_t = B_1 X_{t-1} + B_2 X_{t-2} + \epsilon_t \quad (1)$$

The model assumes that the error term (ϵ_t) is distributed normally and not serially correlated across time.

B_0 represents the contemporaneous relationships identified as follows:

$$B_0 = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 & 0 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & 0 & 0 & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 & 0 & 0 \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & 1 & 0 \\ a_{81} & a_{82} & a_{83} & a_{84} & a_{85} & a_{86} & a_{87} & 1 \end{pmatrix}$$

B_1, B_2 are structural parameters on the lagged variables. There are no lag ($j = 1, 2$) restrictions, which means all variables are related through the lags.

$$B_j = \begin{pmatrix} a_{11}{}^j & a_{12}{}^j & a_{13}{}^j & a_{14}{}^j & a_{15}{}^j & a_{16}{}^j & a_{17}{}^j & a_{18}{}^j \\ a_{21}{}^j & a_{22}{}^j & a_{23}{}^j & a_{24}{}^j & a_{25}{}^j & a_{26}{}^j & a_{27}{}^j & a_{28}{}^j \\ a_{31}{}^j & a_{32}{}^j & a_{33}{}^j & a_{34}{}^j & a_{35}{}^j & a_{36}{}^j & a_{37}{}^j & a_{38}{}^j \\ a_{41}{}^j & a_{42}{}^j & a_{43}{}^j & a_{44}{}^j & a_{45}{}^j & a_{46}{}^j & a_{47}{}^j & a_{48}{}^j \\ a_{51}{}^j & a_{52}{}^j & a_{53}{}^j & a_{54}{}^j & a_{55}{}^j & a_{56}{}^j & a_{57}{}^j & a_{58}{}^j \\ a_{61}{}^j & a_{62}{}^j & a_{63}{}^j & a_{64}{}^j & a_{65}{}^j & a_{66}{}^j & a_{67}{}^j & a_{68}{}^j \\ a_{71}{}^j & a_{72}{}^j & a_{73}{}^j & a_{74}{}^j & a_{75}{}^j & a_{76}{}^j & a_{77}{}^j & a_{78}{}^j \\ a_{81}{}^j & a_{82}{}^j & a_{83}{}^j & a_{84}{}^j & a_{85}{}^j & a_{86}{}^j & a_{87}{}^j & a_{88}{}^j \end{pmatrix}$$

Non-recursive VAR: This identification differs from the recursive VAR with two main assumptions related to foreign resource sector variables and monetary policy. Firstly, Chinese industrial production and the export price are block exogenous, meaning that there is no feedback from the Mongolian variables to those variables either contemporaneously or through the lags. However, there is feedback between the foreign variables.

Another restriction is that foreign variables (*ip_cn* and *px*) do not directly influence the domestic price or policy interest rate. In order words, it is assumed that the domestic price level is not affected contemporaneously but is impacted in a lagged way by foreign variables. The monetary policy reaction is consistent with a Mongolian policy reaction function consisting of the output gap, inflation deviation from the target and real exchange rate gap.

The contemporaneous relationships are identified as follows:

$$B_0 = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 & 0 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & a_{65} & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & a_{75} & a_{76} & 1 & a_{78} \\ a_{81} & a_{82} & a_{83} & a_{84} & a_{85} & a_{86} & a_{87} & 1 \end{pmatrix}$$

Lag ($j = 1, 2$) restrictions are identified as follows, excluding lagged feedback from other variables to Chinese industrial production and the export price index.

$$B_j = \begin{pmatrix} {a_{11}}^j & {a_{12}}^j & 0 & 0 & 0 & 0 & 0 & 0 \\ {a_{21}}^j & {a_{22}}^j & 0 & 0 & 0 & 0 & 0 & 0 \\ {a_{31}}^j & {a_{32}}^j & {a_{33}}^j & {a_{34}}^j & {a_{35}}^j & {a_{36}}^j & {a_{37}}^j & {a_{38}}^j \\ {a_{41}}^j & {a_{42}}^j & {a_{43}}^j & {a_{44}}^j & {a_{45}}^j & {a_{46}}^j & {a_{47}}^j & {a_{48}}^j \\ {a_{51}}^j & {a_{52}}^j & {a_{53}}^j & {a_{54}}^j & {a_{55}}^j & {a_{56}}^j & {a_{57}}^j & {a_{58}}^j \\ {a_{61}}^j & {a_{62}}^j & {a_{63}}^j & {a_{64}}^j & {a_{65}}^j & {a_{66}}^j & {a_{67}}^j & {a_{68}}^j \\ {a_{71}}^j & {a_{72}}^j & {a_{73}}^j & {a_{74}}^j & {a_{75}}^j & {a_{76}}^j & {a_{77}}^j & {a_{78}}^j \\ {a_{81}}^j & {a_{82}}^j & {a_{83}}^j & {a_{84}}^j & {a_{85}}^j & {a_{86}}^j & {a_{87}}^j & {a_{88}}^j \end{pmatrix}$$

2. **Markov-Switching VAR.** The model defines the asymmetric relationship between the variables. The identification is the same as the recursive VAR model, but parameters are different depending on the regime.

   Hamilton (1989) introduced different behaviour and asymmetry of the business cycle using unobserved Markov switching states. The Markov-switching VAR model identifies time-dependent parameters and transition probabilities between variables in the system, from which it produces regime-dependent impulse responses. This approach allows for a better understanding of the boom and bust cycle as well as to separately estimate the effects of shocks depending on what cycle the economy is in. The mathematical expression of a Markov-switching VAR is described below following Ehrmann et al. (2003).

$$X_t = \begin{cases} v_1 + B_{11}X_{t-1} + +B_{21}X_{t-2} + A_1 u_t & if\ s_t = 1 \\ v_2 + B_{12}X_{t-1} + +B_{22}X_{t-2} + A_2 u_t & if\ s_t = 2 \end{cases} \tag{2}$$

$$u_t \sim N(0; I)$$

Where: it is assumed that there are two lags and two regimes. u_t has the same assumptions as the error term of ordinary VAR models. However, the error terms are multiplied by a regime-dependent matrix A_i. So, the variance-covariance matrix of the residuals is also regime-dependent.

Another important assumption is that a regime follows a two-state Markov-Chain, where the next period state (i) is dependent on the current state (j). Therefore, the conditional transition probabilities to change a state are defined in a P matrix as defined by equation (3).

$$Pr(s_{t+1} = j | s_t = i) = \rho_{ij}$$

$$P = \begin{bmatrix} \rho_{11} & \rho_{12} \\ \rho_{21} & \rho_{22} \end{bmatrix} \tag{3}$$

Where ρ_{ij} is the probability of being under regime j after regime i. For example, ρ_{11} is the probability of staying in regime 1 while ρ_{22} is the probability of staying in regime 2. ρ_{12} is transition probability of changing to regime 2 from regime 1.

From the estimation result, the probability matrix (P) is extracted as follows (Appendix 6):

$$P = \begin{bmatrix} \rho_{11} & \rho_{12} \\ \rho_{21} & \rho_{22} \end{bmatrix} = \begin{bmatrix} 0.93 & 0.07 \\ 0.06 & 0.94 \end{bmatrix}$$

It is clear from the probabilities that the regimes are stable. Using these propabilities to determine regime duration (following Hamilton 1989), the duration of regime 1 (boom cycles) is 14 quarters, and that of regime 2 (bust cycle) is 17 quarters. Regime probabilities are computed for each period in the whole sample, and the smoothed probabilities of being in either regime 1 or regime 2 are provided in Appendix 7. The model predicts three downturn cycles in 2005, 2008 and 2013, which accords with the data.

III. EMPIRICAL RESULTS

This section provides impulse response analyses for resource sector related shocks, followed by forecast error variance and historical decomposition for Mongolian output using the VAR models described in Section 2.

3.1 Resource sector-related shocks

Three types of shocks are analysed to identify the effects of resource sector shocks on the Mongolian economy. The impulse responses to Chinese industrial production, export price index and mining export shocks are depicted in Figures 1 to 3 respectively. Each figure compares the impulse response functions for a one standard deviation shock over 60 quarters. The blue lines illustrate the results of the recursive VAR model while double blue lines represent the non-recursive model. The results of the Markov-Switching VAR model depicted with black lines; dashed for booming periods and dotted for downturns. The impulse responses with corresponding confidence intervals are provided in Appendix 8. Because of the high volatility in the Mongolian economy as well as the small sample, impulse responses are statistically insignificant. However, the consistency of the estimations provides robustness.

From the results, Chinese industrial production and price shocks produce similar transmissions to the economy. However, the responses differ depending on the business cycle stage due to differences in the economic outlook of investors. The resource supply shock is relatively short-lived.

Chinese industrial production shock (figure 1): From the impulse response functions of the three models, an increase in Chinese Industrial production generally leads to a higher export price, which stimulates mining sector activity. The positive demand for resources additionally attracts investment into the sector. Higher mining sector exports and FDI together boost overall economic activity. A consequence of this is higher inflation as the economy overheats, which prompts a tightening of monetary policy. The initial drop of the policy rate results from domestic currency appreciation due to an increased supply of foreign currency from both mining exports and FDI. Despite the domestic currency appreciating, there is no significant decline in GDP; in fact the overall impact on output is positive. In order words, there is no evidence of Dutch disease in the Mongolian case.

Responses differ depending on the business cycle stage. When the economy is in a downturn, the effects of a Chinese industrial production shock will be limited by the dampened expectations of investors on the economic outlook. The expectations are mostly formed on current economic circumstances. So investors expect lower growth when there is a recession and become more cautious about investing. This expectation appears in the FDI movements during the downturn period, with FDI much lower than in the boom period. FDI falls initially because of the lower interest rate resulting from the exchange rate appreciation as well as a lower inflation rate. Overall weaker expectations and lower investment lessen the impact of Chinese industrial production shocks on the broader economy.

On the contrary, if the economy is booming and a positive Chinese industrial production shock occurs, the transmission to the overall economy will be magnified by higher expectations and investment. Output peaks between 0.4 per cent to 0.9 per cent in response to the initial increase in Chinese industrial production during a downturn while the peak in output for an upturn period is 1.7 per cent to 1.8 per cent after eight quarters. The total impact is 1.5 per cent and 0.4 per cent in boom and bust periods respectively.

If the impacts are assumed to be asymmetric, the effect magnitudes fall between the two regime results but closer to the boom period since this is associated with a higher probability in the sample. The quarterly GDP deviation peaks at 1.2 per cent after nine quarters and overall accumulated GDP is estimated to be 1.6 per cent higher than the baseline after 15 years.

Introducing non-recursive monetary policy restrictions and making Chinese industrial production and the export price exogenous increases the size and longevity of the impacts. The non-recursive system does not differentiate between regimes. The peak effect on GDP is a 2 per cent increase occurring after 10 quarters. The economy will have 4.7 per cent higher output in total.

Resource price shock (figure 2): Mongolian exports are mostly commodities bound for China. So higher Chinese industrial production translates into higher export prices. The impulse responses follow similar patterns to those of the demand shock.

The main difference is that the price shock involves a more immediate and greater magnitude response in recession periods. In boom times a 6.2 per cent higher export price is responsible for 8.1 per cent total improvement in output, with a single-period peak of 0.7 per cent after eight quarters. In downturns, the total accumulated change of GDP is 6.1 per cent with a single-period peak of 0.6 per cent after 10 quarters to 7.7 per cent initial export price shock.

Resource supply shock (figure 3): Without restricting the channel to export price and Chinese industrial production, the responses of those variables affect changes in other variables. For instance, there is a price decline following a positive mining supply shock during a boom period. Positive spillover effects from FDI further appreciate the domestic currency and trigger a decline in mining exports in subsequent periods. This then causes a depreciation of the exchange rate. Interest rate movements then mostly relate to exchange rate changes. GDP increases initially and then declines, with no lasting overall impact.

By contrast in recession periods, FDI does not rise in response to the mining supply shock. The higher domestic price drop leads to a higher export price which attracts some FDI in following periods. However, the overall impact on the economy is also neutral.

Assuming symmetry in the relationships between variables, impacts become smoother and there is a positive GDP impact from the mining supply increase, peaking at 0.8 per cent in a quarter to 1.2 per cent initial shock of the supply and having 4.3 per cent of the total effect.

Under the non-recursive model, Mongolian mining companies are assumed to have less power to influence the export price. As the export price does not change, the effect of a shock on mining exports is lower. This then translates to a lesser effect on output at 3.4 per cent higher than the baseline overall with a similar peak point to the recursive model.

Figure 1 Impulse responses to a Chinese industrial production shock (one standard deviation)

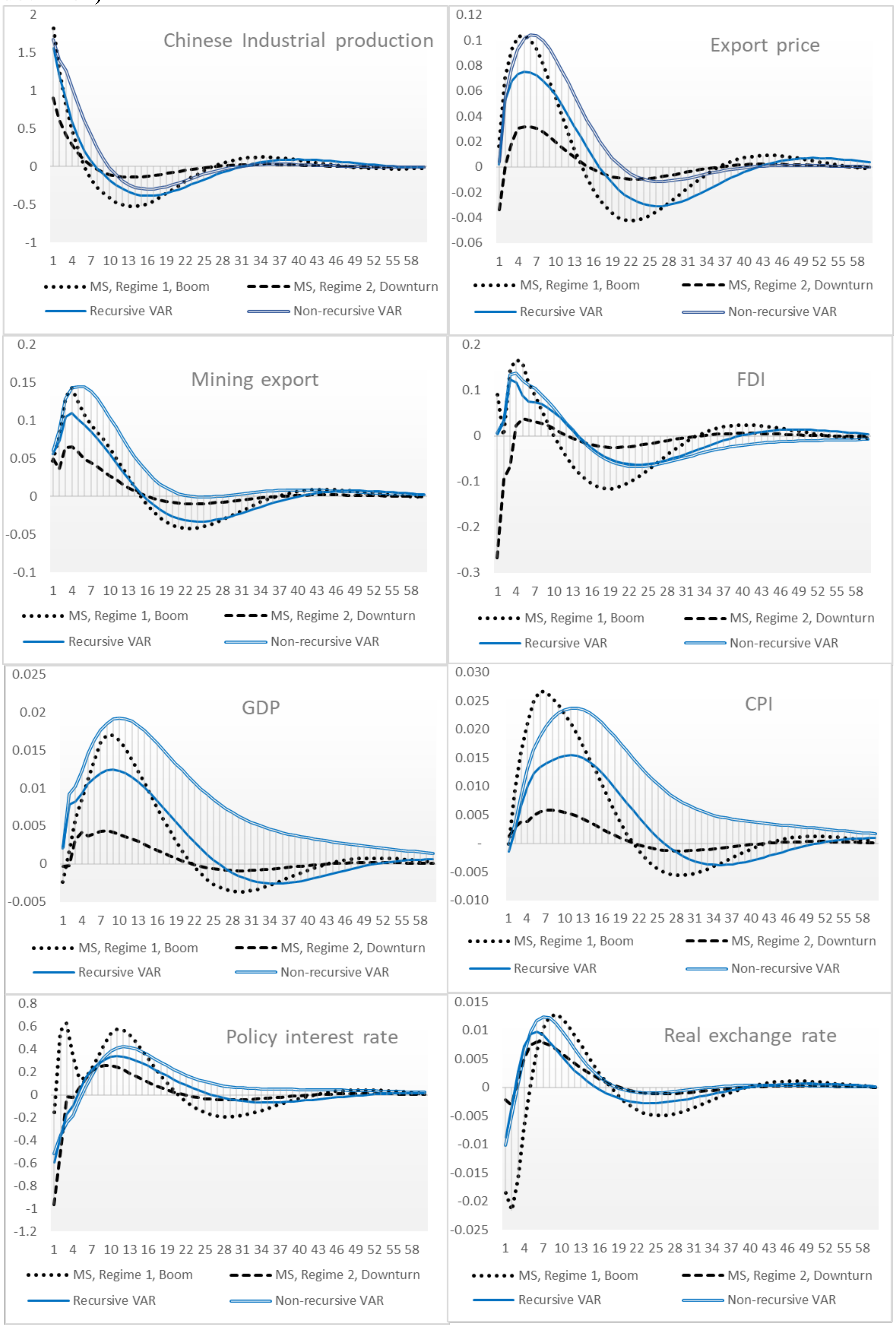


Figure 2 Impulse responses to a resource price shock (one standard deviation of the export price index)

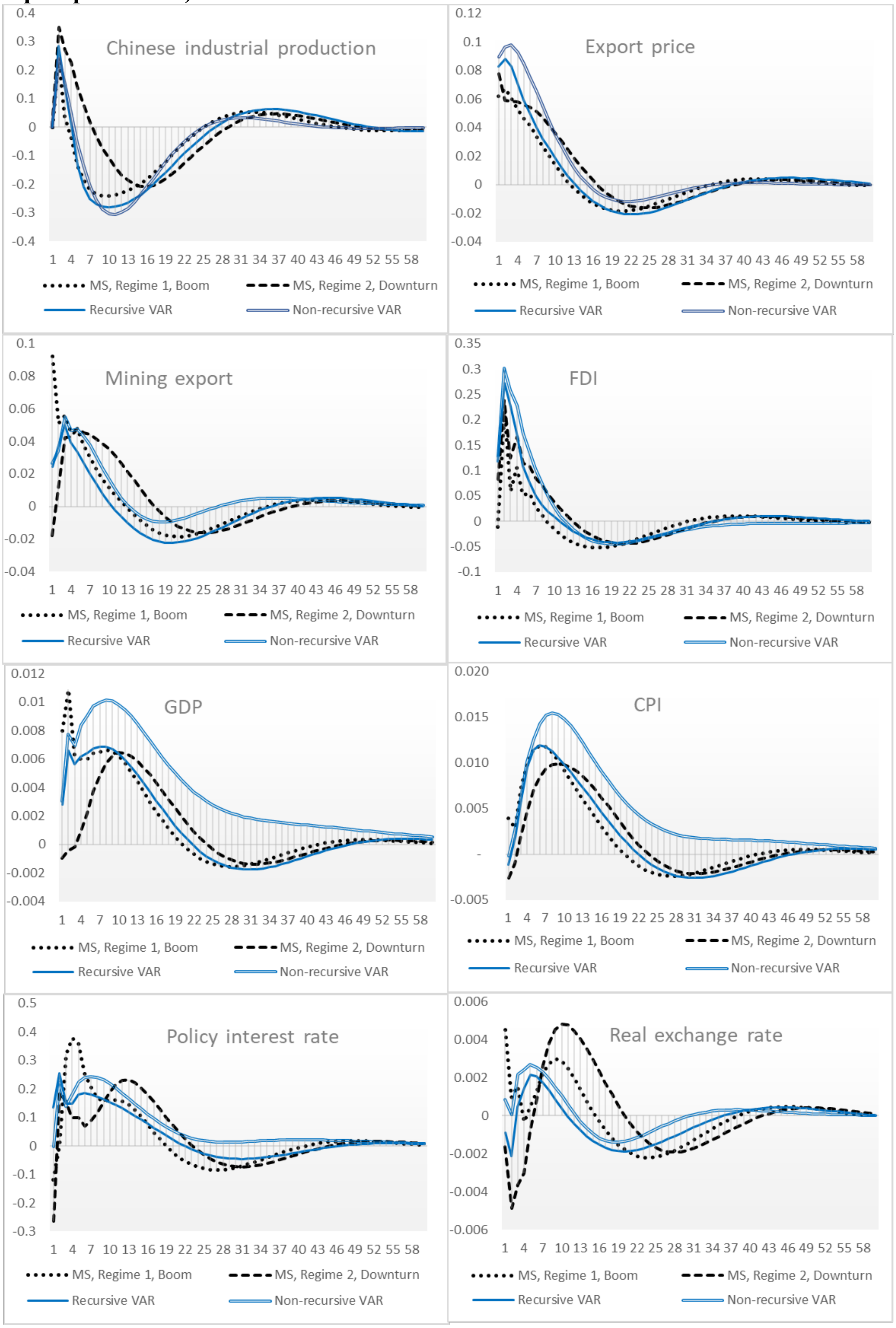
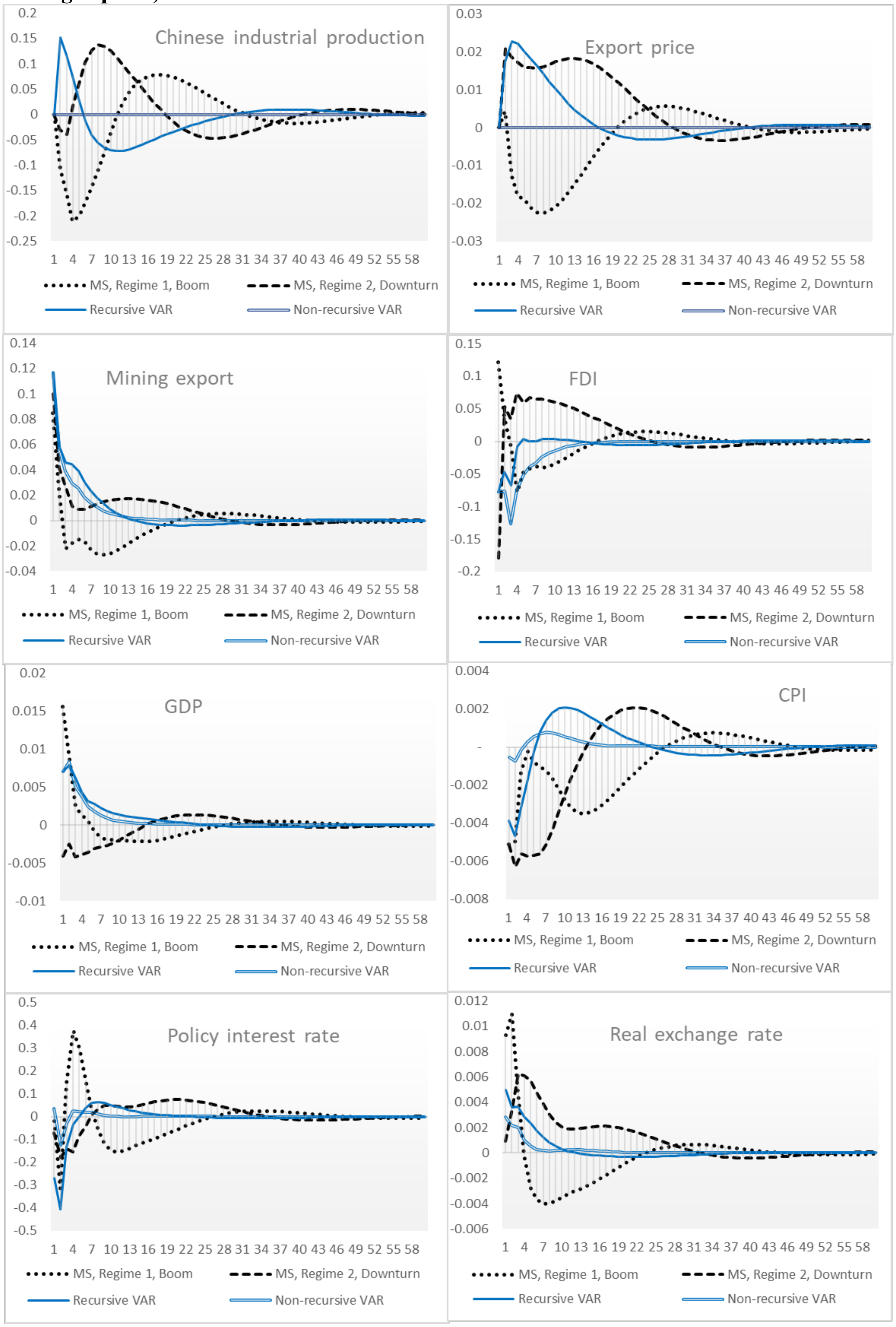


Figure 3 Impulse responses to a resource supply shock (one standard deviation of the mining exports)



3.2 Forecast error variance decomposition of the Mongolian economy

This section analyses the variance decomposition of output (figure 4), explained below based on the results of the VAR models. The Mongolian economy is found to be susceptible to resource sector related shocks. In particular, spillover effects are high in boom periods.

Markov switching VAR model (Figure 4a): Variance of output during boom periods is mostly due to foreign variables, whereas domestic variables are more important in explaining the variance during downturns. The interest rate and real exchange rate are not found to make statistically significant contributions under either regime.

Upturns in the Mongolian economy are mostly explained by foreign variables, which account for about 60 per cent of the variance in the short-run and about 80 per cent in the medium-run. Domestic demand (about 30 per cent), mining exports (30 per cent) and export price shocks (20 per cent) make large contributions in the short-run. In the medium-term, 55 per cent of the variance is triggered by Chinese industrial production, with 14 and 9 per cent from export price index and mining exports, respectively. FDI has low significance in the variance ranging from 9 per cent in quarter 1 to 2 per cent between quarters 13 and 20. Inflation's contribution peaks at 16 per cent in the fifth quarter to reach 10 per cent at the end of the modelled time horizon.

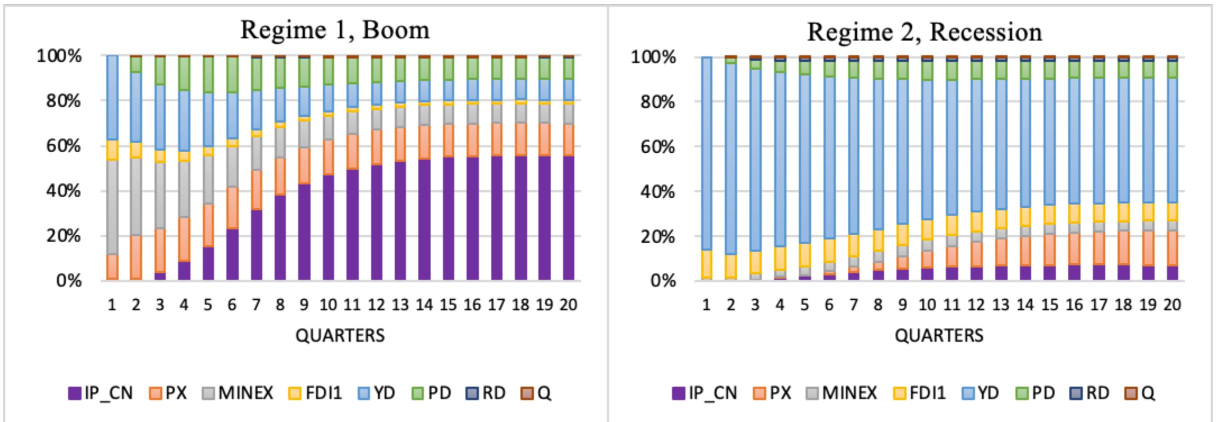
Conversely, output variance in a downturn is mainly caused by domestic shocks where the output shock is the biggest contributor (around 80 per cent in the short run, 55 per cent in the medium term). FDI is the next most important variable, making contributing 10 per cent of first year variance, 8 per cent after five years. 16 per cent of the medium-term variance comes from the export price, which has almost no role in the short-run. The same applies to Chinese industrial production, with its contribution (7 per cent) slightly bigger in the medium-term. Mining exports only explain about 5 per cent of the variance.

Recursive VAR model (figure 4b): According to this model, the variance of domestic output is mostly explained by own shocks contributing 95 per cent of the variance in quarter one and reduces to a sustained 41 per cent after 16 quarters. The significance of foreign variables (Chinese industrial production (34 per cent), export price (10 per cent), mining exports (4 per cent)) is high in the long-run, accounting for almost half of the fluctuation in output. Inflation is responsible for 5 per cent of the output variation in the long run. Other variables (FDI, interest rate, real exchange rate) are not influential to the variance.

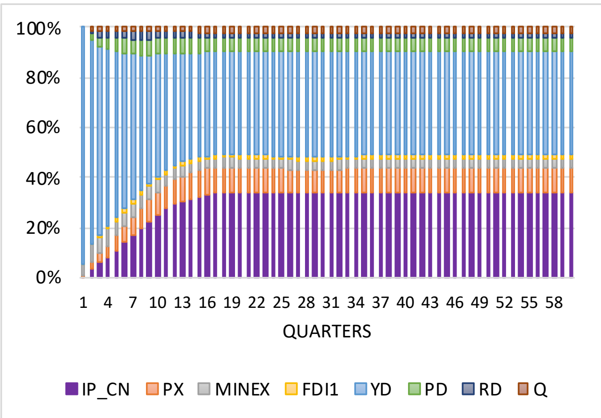
Non-recursive VAR model (Figure 4c): Introducing some restrictions to the previous VAR model, the contribution of Chinese industrial demand (49 per cent) and export prices (12 per cent) become more critical to explaining long-run output variance. Own shocks explain 27 per cent and inflation explains 7 per cent of the output variance.

Figure 4 Variance decomposition of output

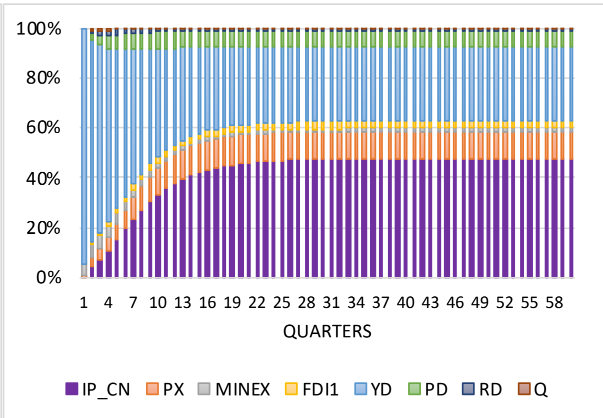
a. Markov switching VAR model



b. Recursive VAR model



c. Non-recursive VAR model



Where: IP_CN: Chinese industrial production shock; PX: Export price shock; MINEX: Mining export shock; FDI1: FDI shock; YD: GDP shock, PD: CPI shock RD: Policy rate shock, Q: Real exchange rate shock.

3.3 Historical decomposition of the Mongolian economy

This section examines the historical resource sector related shocks that deviate output from baseline model projections (Figure 5). The approach most consistent with a historical decomposition of Mongolian economic development comes from the estimation of the Markov switching VAR model.

Markov switching VAR model (Figure 5a): Economic output is found to be below projections except for periods just after financial crises. From mid-2010 to mid-2015, output exceeds projections and after that remains fairly consistent until 2019. In 2019, shocks kept output below its baseline forecast.

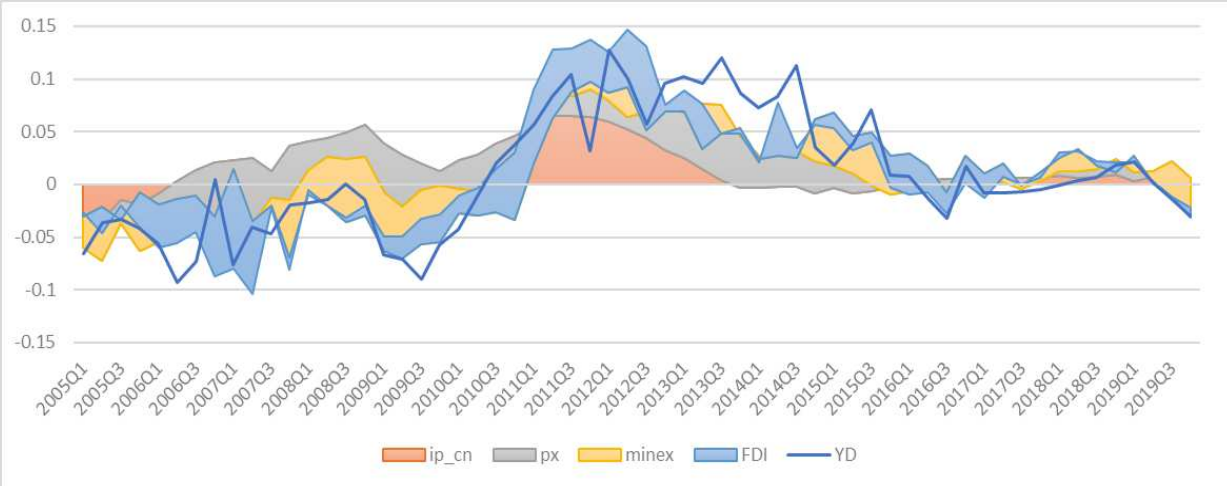
Export prices tend to push the economy above projections during financial crises (2007-2009), whereas mining exports and FDI provide negative shocks lowering output below projections, which suggests investors are cautious about investing in developing economies during such periods. Between 2010-2015, overheating of the economy was caused by Chinese industrial demand, export prices, FDI and mining exports. The shocks were almost neutralised in the following period (2015-2018), with GDP not deviating considerably from projections. The economy falls below the projection because of a mining export shock in 2019, which is consistent with a border closure of 2019.

Recursive VAR model (Figure 5b): General patterns follow the Markov switching VAR model, however the magnitudes of the foreign shocks are smaller. Another difference is that the Chinese industrial production shock has kept the Mongolian economy below projection since 2017.

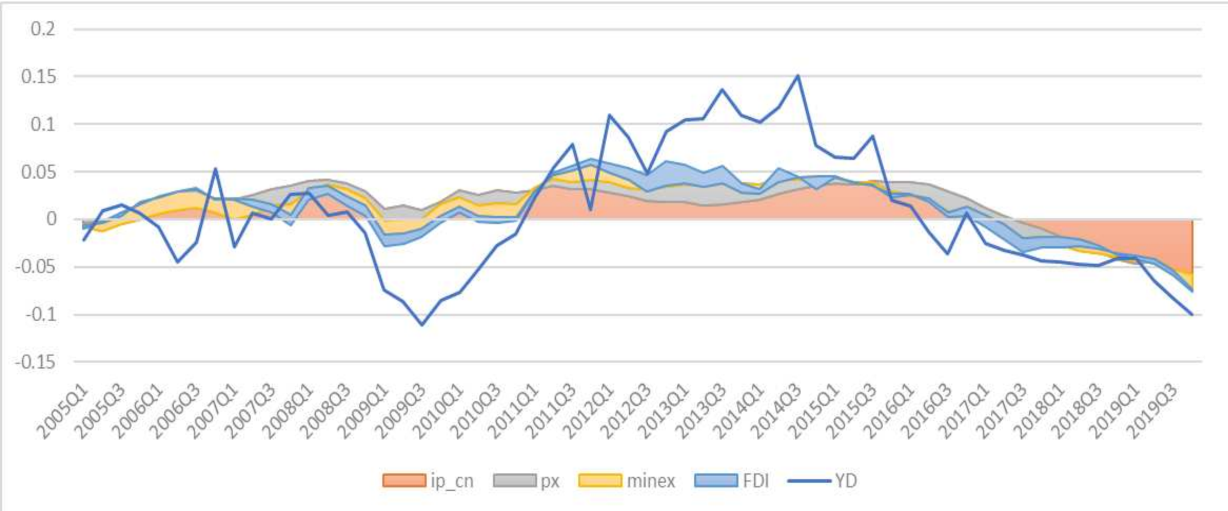
Non-recursive VAR model (Figure 5c): In this case, most deviations of output from projections are explained by Chinese industrial production.

Figure 5 Historical decomposition of output

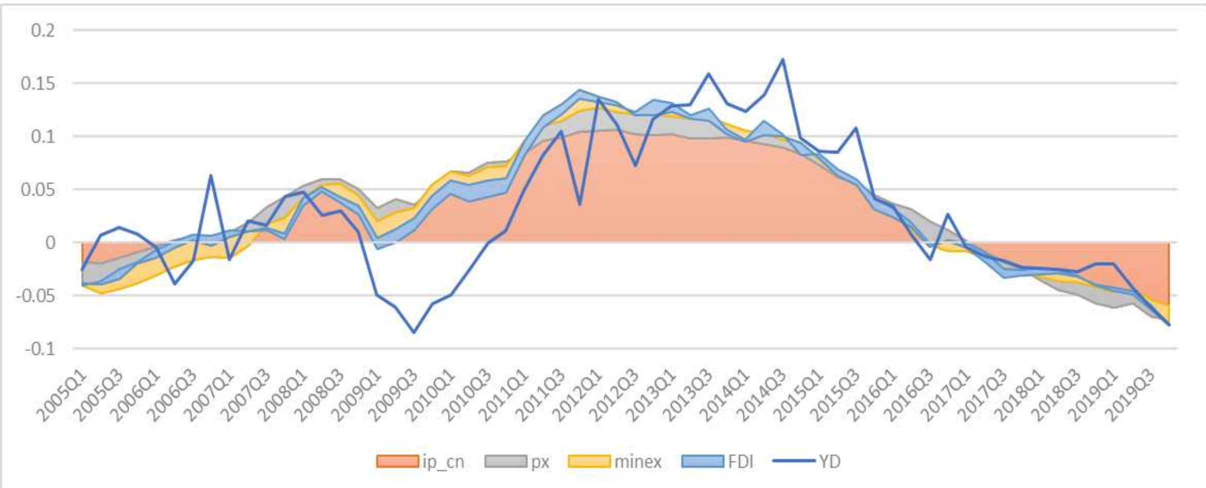
a. **Markov switching VAR model**



b. **Recursive VAR model**



c. **Non-recursive VAR model**



IV. CONCLUSION

This paper examined the transmission channels and overall impact of resource shocks on the Mongolian economy, contributing to empirical evidence on Dutch disease. It also examined asymmetric relationships between variables depending on the business cycle.

Three kinds of VAR models were used to study resource sector related shocks on the Mongolian economy. Chinese industrial production, resource price and resource supply shocks were separately analysed.

Impulse response functions suggest that Chinese industrial production and price shocks exhibit similar behaviour. This is because Mongolian companies have little influence on export prices, which only change with demand. Generally, the magnitude and duration of shock impacts on the Mongolian economy are large. Positive shocks are magnified during boom periods due to high spillover effects of FDI, while the sluggish FDI response in recessions lessens the overall impact on the economy. The magnitude and duration of impacts become even larger under stricter assumptions of shock exogeneity. Mining export shocks are relatively short-lived. FDI behaviour is also different depending on regimes. In the non-recursive model, sizes of the impacts are smaller than the recursive model.

From the forecast variance decompositions, resource-related shocks are found to be an important factor explaining changes to the Mongolian economy. Particularly in booming periods, spillover effects of resource shocks are high. Historical decomposition, of which the Markov-switching model seems the most realistic, evidenced that the cautiousness of investors during financial crises constrained resource sector shocks, even though the export price has an expansionary impact. Overheating, starting from mid of 2010 is mostly caused resource sector booming, where positive shocks for all of the variables (demand, supply, and investment) happens. End of the period, there are the export supply constraints, which pushes the Mongolian economy below its baseline projection.

The overall analysis highlights how resource effects differ depending on the business cycle stage. The root of the difference relates to agents' expectations, as evidenced in the results for FDI. The results also find no significant crowding-out effects; instead suggesting positive spillover effects. Lastly, the study demonstrates that the Mongolian business cycle is susceptible to resource sector related shocks. Macroeconomic policies should consider the nature of the shocks as well as business cycles effects on macroeconomic volatility.

Further improvements would be introducing restrictions on the Markov-switching VAR model and using Bayesian approaches that could give another detailed insight into resource transmission.

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APPENDIX

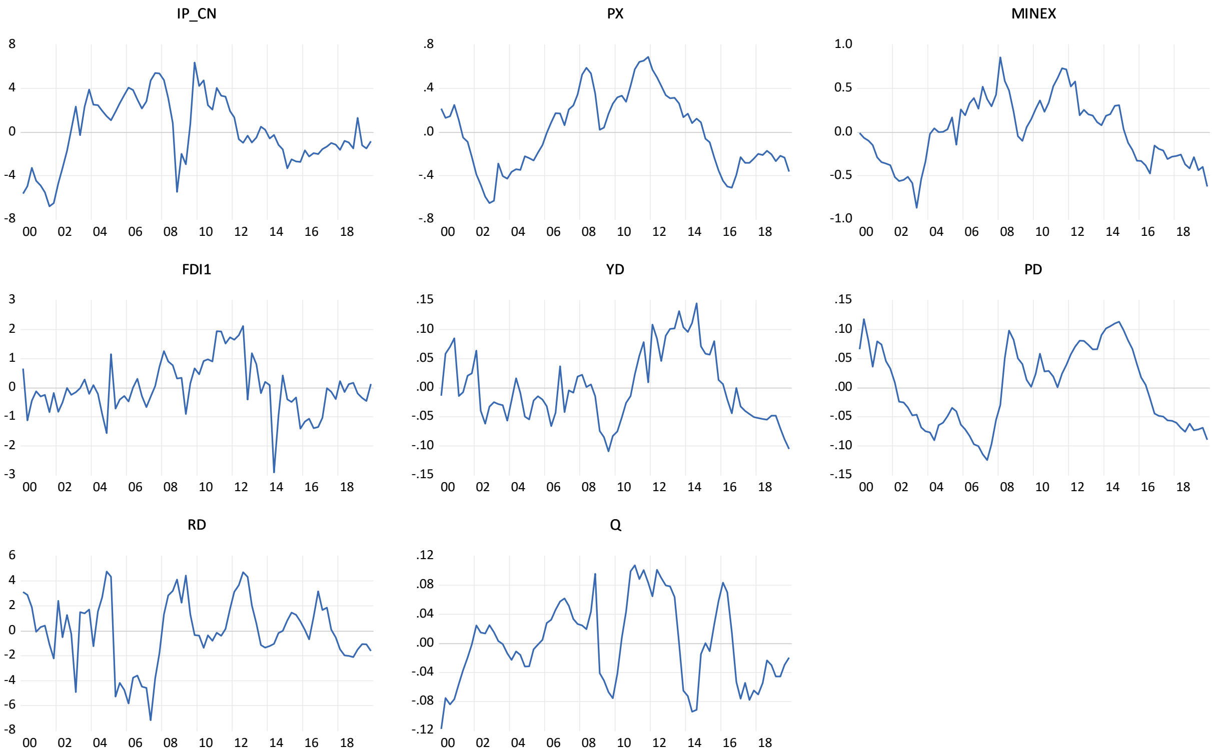
Appendix 1 Variables' description and source

Code	Description	Availability	Source
ip_cn	Chinese industrial production yearly growth	2000M1-2019M12	Bloomberg
px	Log of export price index /USD/;	2000M1-2019M12	BoM
Minex	Log of mining export /USD/; Using the seasonal factors of 2004, data from 2000 to 2003 are converted into quarterly.	2003M1-2019M12 Yearly: 2000-2003	NSO
FDI	Log of FDI /USD/;	2000Q1-2019Q4 2008M1-2019M12	BoM
yd	Log of real GDP in domestic currency	2000Q1-2019Q4	National Statistical Office of Mongolia (NSO)
pd	Log of CPI index for Ulaanbaatar	2000M1-2019M12	NSO
rd	Policy interest rate	2000M1-2019M12	Monthly bulletin, Bank of Mongolia (BoM)
q	Real effective exchange rate /Trade weighted/	2000M1-2019M12	BoM

Appendix 2 Descriptive statistics. The data are demeaned and detrended.

Sample: 2000Q1 2019Q4								
	IP_CN	**PX**	**MINEX**	**FDI1**	**YD**	**PD**	**RD**	**Q**
Mean	-0.00	0.00	0.00	-0.00	0.00	0.00	0.00	-0.00
Median	-0.42	0.01	0.00	-0.15	-0.01	0.00	-0.04	-0.00
Maximum	6.36	0.69	0.86	2.12	0.14	0.12	4.76	0.11
Minimum	-6.83	-0.65	-0.87	-2.91	-0.11	-0.12	-7.17	-0.12
Std. Dev.	3.09	0.34	0.37	0.90	0.06	0.07	2.63	0.06
Skewness	-0.12	0.15	0.08	0.11	0.50	0.06	-0.39	0.12
Kurtosis	2.35	2.06	2.27	3.75	2.37	1.66	2.88	2.08
Observations	80	80	80	80	80	80	80	80

Appendix 3 Plots of the data (2000Q1 to 2019Q4)



Appendix 4 VAR Lag Order Selection

VAR Lag Order Selection Criteria
Endogenous variables: IP_CN PX MINEX FDI1 YD PD RD Q
Exogenous variables: C
Date: 10/14/20 Time: 00:02
Sample: 2000Q1 2019Q4
Included observations: 73

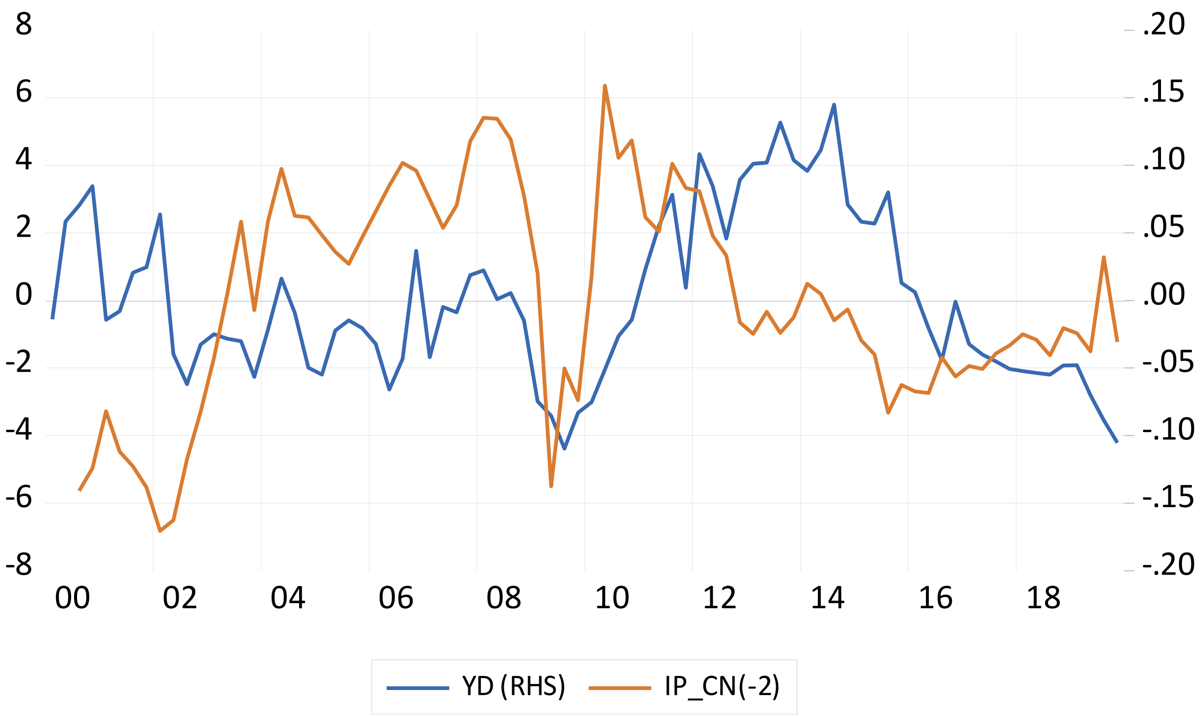
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-31.54	NA	4.08e-10	1.083200	1.334209	1.183231
1	333.98	640.9087	1.07e-13	-7.177574	-4.918491*	-6.277290
2	378.33	68.04276	1.94e-13	-6.639199	-2.372041	-4.938663
3	425.80	62.42935	3.58e-13	-6.186385	0.088846	-3.685597
4	520.13	103.3735	2.17e-13	-7.017299	1.266006	-3.716259
5	605.55	74.88804	2.23e-13	-7.604126	2.687254	-3.502833
6	735.63	85.53044	1.09e-13	-9.414470	2.884984	-4.512925
7	936.57	88.08223*	1.88e-14*	-13.16618*	1.141343	-7.464388*

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

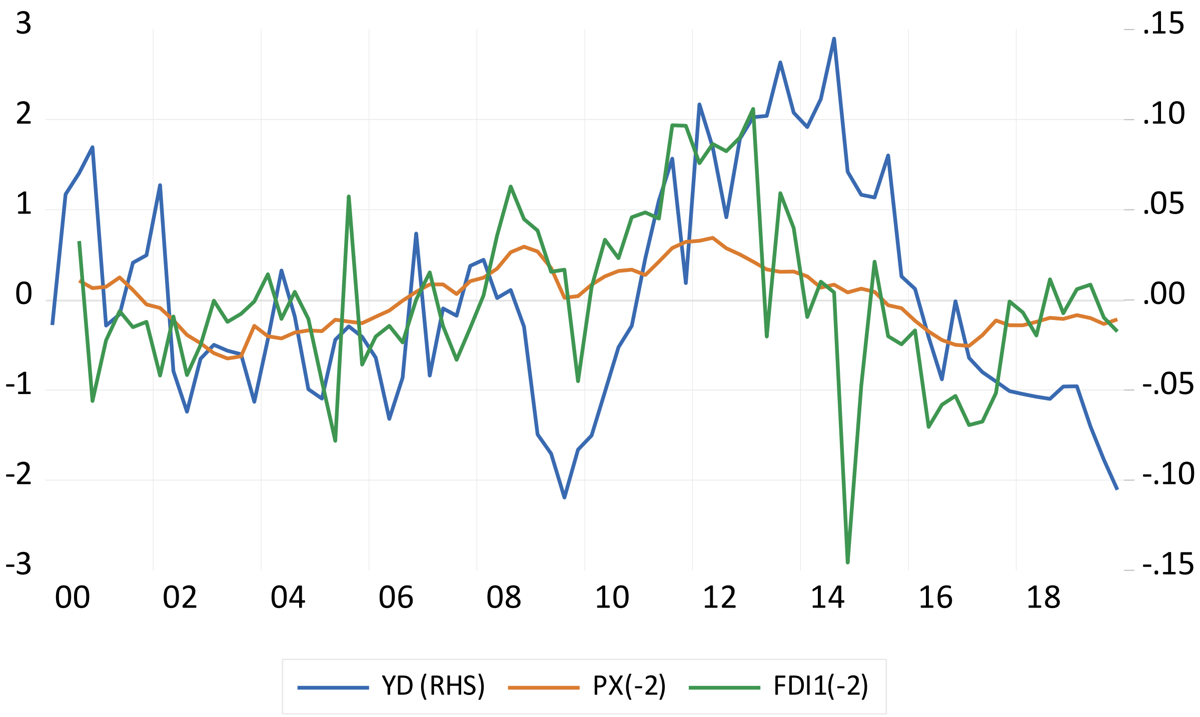
VAR Lag Exclusion Wald Tests
Sample (adjusted): 2001Q4 2019Q4
Included observations: 73 after adjustments
Chi-squared test statistics for lag exclusion:
Numbers in [ ] are p-values

	IP_CN	PX	MINEX	FDI1	YD	PD	RD	Q	Joint
Lag 1	12.30	26.59	7.15	13.14	7.39	98.60	22.05	14.52	493.51
	[0.1384]	[0.0008]	[0.5211]	[0.1071]	[0.4951]	[0.0000]	[0.0048]	[0.0691]	[0.0000]
Lag 2	16.16	6.95	3.06	4.76	3.90	14.89	6.69	5.93	147.28
	[0.0401]	[0.5420]	[0.9307]	[0.7834]	[0.8658]	[0.0612]	[0.5700]	[0.6553]	[0.0000]
Lag 3	9.92	8.46	4.03	3.95	5.71	6.72	9.83	4.49	69.20
	[0.2708]	[0.3899]	[0.8548]	[0.8612]	[0.6797]	[0.5676]	[0.2774]	[0.8109]	[0.3062]
Lag 4	13.92	8.50	8.48	16.40	7.11	27.52	22.05	10.97	271.73
	[0.0839]	[0.3865]	[0.3880]	[0.0370]	[0.5244]	[0.0006]	[0.0048]	[0.2037]	[0.0000]
Lag 5	14.88	9.01	4.58	6.51	9.83	26.23	12.88	6.39	204.48
	[0.0615]	[0.3416]	[0.8012]	[0.5902]	[0.2771]	[0.0010]	[0.1159]	[0.6041]	[0.0000]
Lag 6	7.82	14.91	3.95	15.68	4.31	25.38	3.86	2.38	215.05
	[0.4508]	[0.0608]	[0.8616]	[0.0472]	[0.8278]	[0.0013]	[0.8694]	[0.9669]	[0.0000]
Lag 7	6.89	8.39	3.86	10.97	8.51	39.70	11.82	3.28	226.82
	[0.5484]	[0.3963]	[0.8693]	[0.2031]	[0.3851]	[0.0000]	[0.1593]	[0.9154]	[0.0000]
df	8	8	8	8	8	8	8	8	64

Mongolian output vs Chinese Industrial Production with two-quarter lag

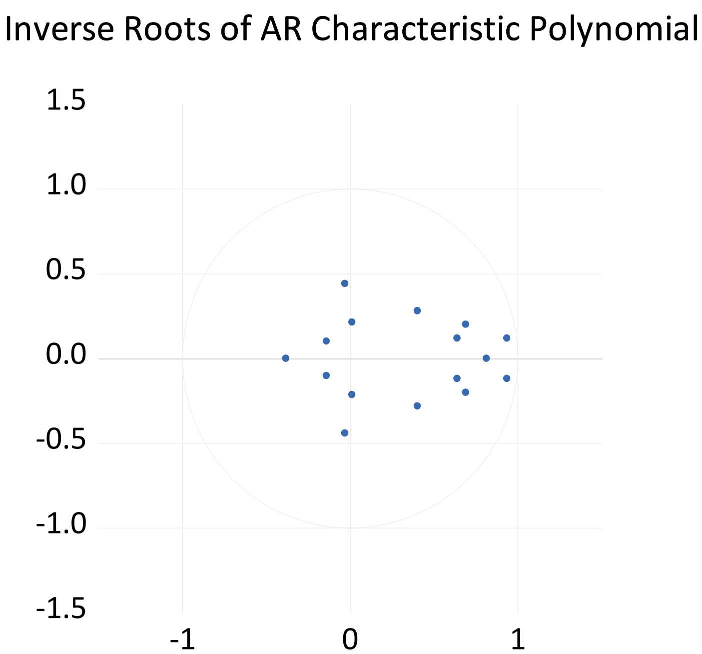


Mongolian output vs Export price index and FDI with two-quarter lag



Appendix 5 Stability tests

5.1 Recursive VAR model

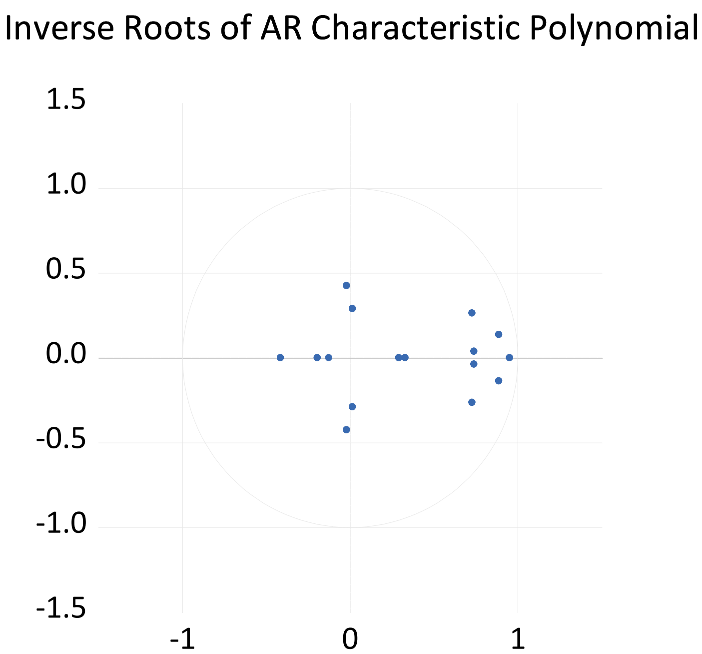


Roots of Characteristic Polynomial
Endogenous variables: IP_CN PX MINEX FDI1 YD PD RD Q
Exogenous variables: C
Lag specification: 1 2

Root	Modulus
0.935382 - 0.118944i	0.94
0.935382 + 0.118944i	0.94
0.813648	0.81
0.689492 - 0.200185i	0.72
0.689492 + 0.200185i	0.72
0.638738 - 0.120023i	0.65
0.638738 + 0.120023i	0.65
0.401323 - 0.281158i	0.49
0.401323 + 0.281158i	0.49
-0.030890 - 0.440561i	0.44
-0.030890 + 0.440561i	0.44
-0.382998	0.38
0.012278 - 0.214023i	0.21
0.012278 + 0.214023i	0.21
-0.140897 - 0.101245i	0.17
-0.140897 + 0.101245i	0.17

No root lies outside the unit circle.
VAR satisfies the stability condition.

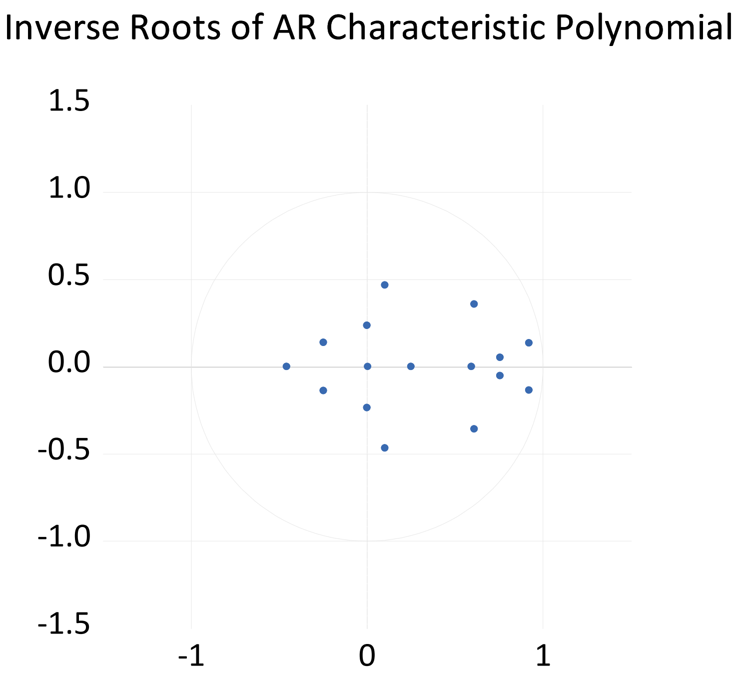
5.2 Non-recursive VAR model



Roots of Characteristic Polynomial Endogenous variables: IP_CN PX MINEX FDI1 YD PD RD Q Exogenous variables: C Lag specification: 1 2	
Root	Modulus
0.951877	0.95
0.887193 - 0.137288i	0.90
0.887193 + 0.137288i	0.90
0.727238 - 0.263606i	0.77
0.727238 + 0.263606i	0.77
0.739581 - 0.038462i	0.74
0.739581 + 0.038462i	0.74
-0.019671 - 0.424782i	0.43
-0.019671 + 0.424782i	0.43
-0.415492	0.42
0.329079	0.33
0.290820	0.29
0.014902 - 0.289491i	0.29
0.014902 + 0.289491i	0.29
-0.195359	0.20
-0.126298	0.13
No root lies outside the unit circle. VAR satisfies the stability condition.	

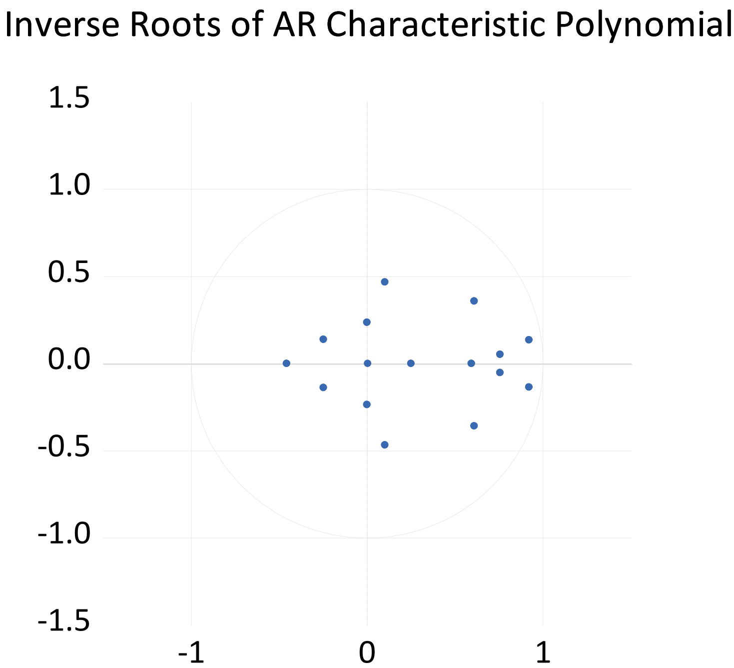
5.3 Markov Switching VAR model

5.3.1 Regime 1



Roots of Characteristic Polynomial Endogenous variables: IP_CN PX MINEX FDI1 YD PD RD Q Exogenous variables: C Lag specification: 1 2	
Root	Modulus
0.921359 - 0.135683i	0.93
0.921359 + 0.135683i	0.93
0.756422 - 0.052052i	0.76
0.756422 + 0.052052i	0.76
0.609573 - 0.357811i	0.71
0.609573 + 0.357811i	0.71
0.593908	0.59
0.102608 - 0.467829i	0.48
0.102608 + 0.467829i	0.48
-0.457772	0.46
-0.248028 - 0.137791i	0.28
-0.248028 + 0.137791i	0.28
0.250395	0.25
0.000203 - 0.235781i	0.24
0.000203 + 0.235781i	0.24
0.004424	0.00
No root lies outside the unit circle. VAR satisfies the stability condition.	

5.3.2 Regime 2



Roots of Characteristic Polynomial	
Endogenous variables: IP_CN PX MINEX FDI1 YD PD RD Q	
Exogenous variables: C	
Lag specification: 1 2	
Root	Modulus
0.921359 - 0.135683i	0.93
0.921359 + 0.135683i	0.93
0.756422 - 0.052052i	0.76
0.756422 + 0.052052i	0.76
0.609573 - 0.357811i	0.71
0.609573 + 0.357811i	0.71
0.593908	0.59
0.102608 - 0.467829i	0.48
0.102608 + 0.467829i	0.48
-0.457772	0.46
-0.248028 - 0.137791i	0.28
-0.248028 + 0.137791i	0.28
0.250395	0.25
0.000203 - 0.235781i	0.24
0.000203 + 0.235781i	0.24
0.004424	0.00
No root lies outside the unit circle.	
VAR satisfies the stability condition.	

Appendix 6 Transition summary: Constant Markov transition probabilities and expected durations

Sample (adjusted): 2000Q3 2019Q4
Included observations: 78 after adjustments

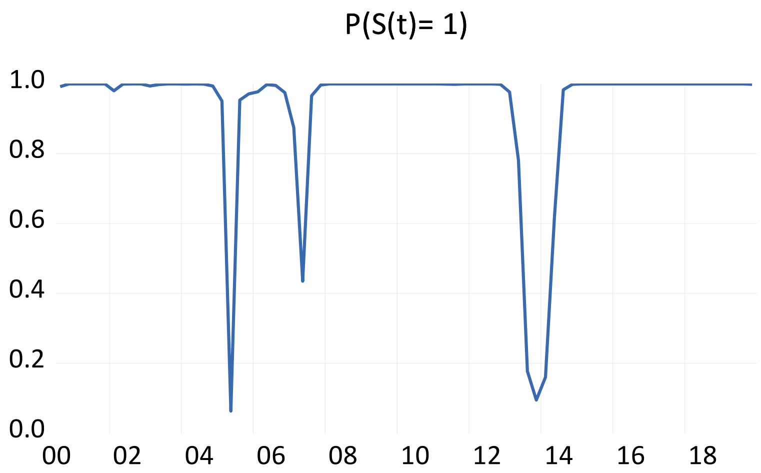
Constant transition probabilities:
P(i, k) = P(s(t) = k | s(t-1) = i)
(row = i / column = k)

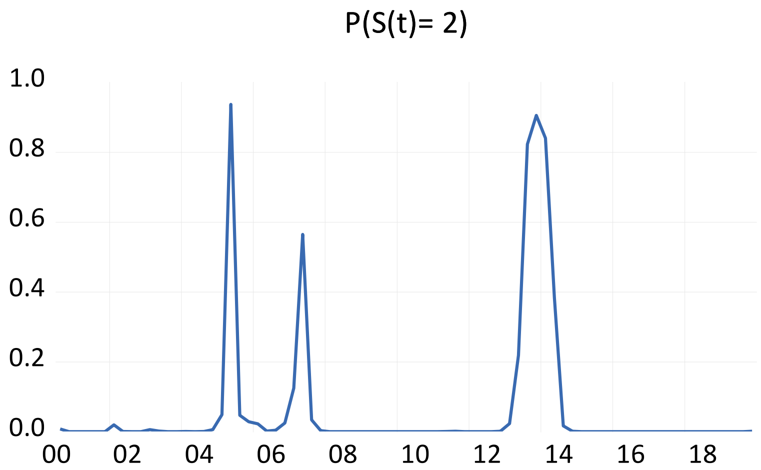
	1	2
1	0.93	0.07
2	0.06	0.94

Constant expected durations:

	1	2
	13.99	16.68

Appendix 7 Markov Switching Smoothed Regime Probabilities (2000Q1 to 2019Q4)



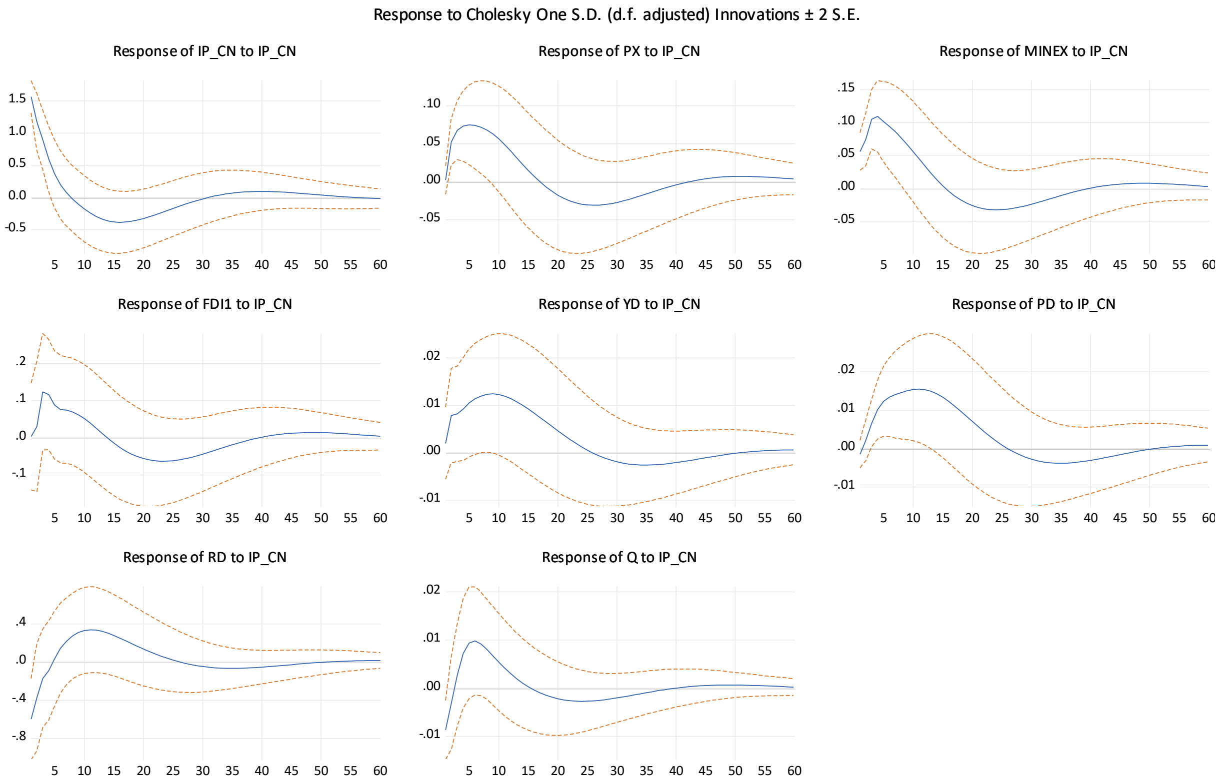


Appendix 8. Impulse responses with confidence intervals over 60 quarters

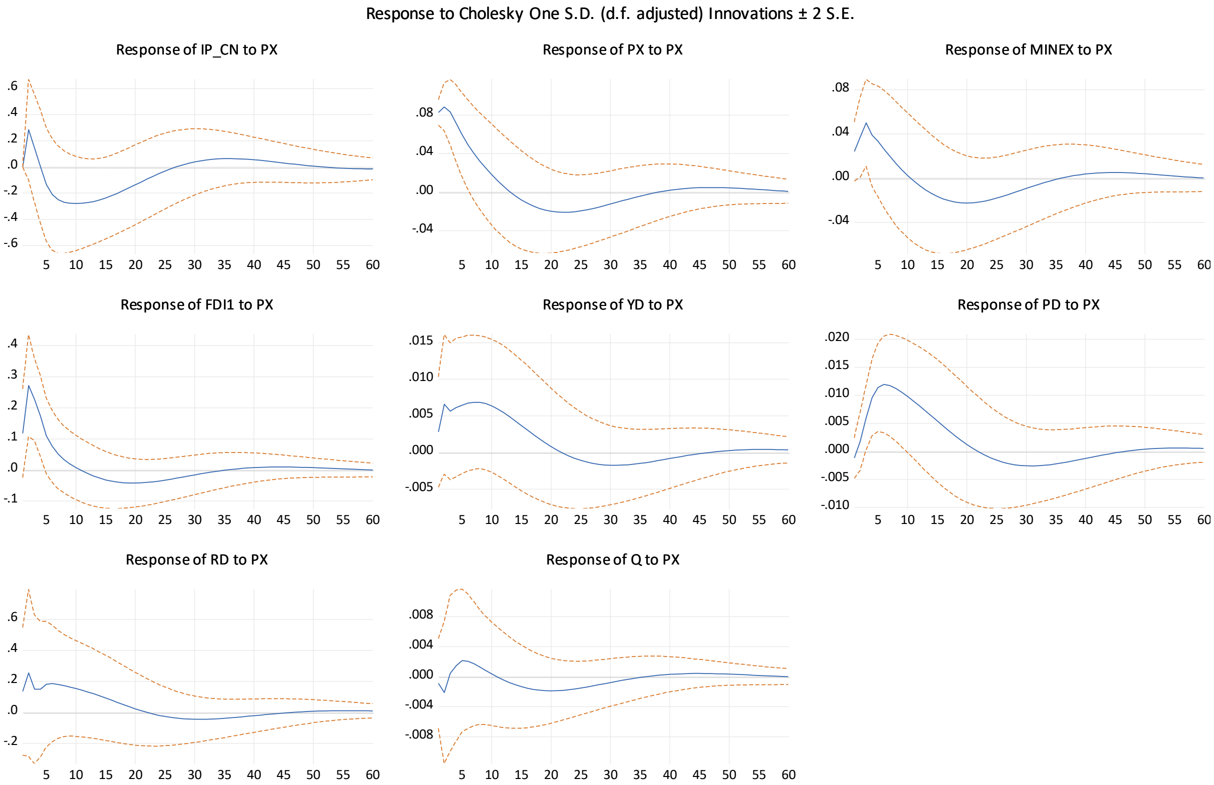
Solid lines are the impulse responses and dashed lines illustrate confidence intervals which are drawn using 10th and 90th percentile values of 1000 bootstrap simulations.

8.1 Recursive VAR model

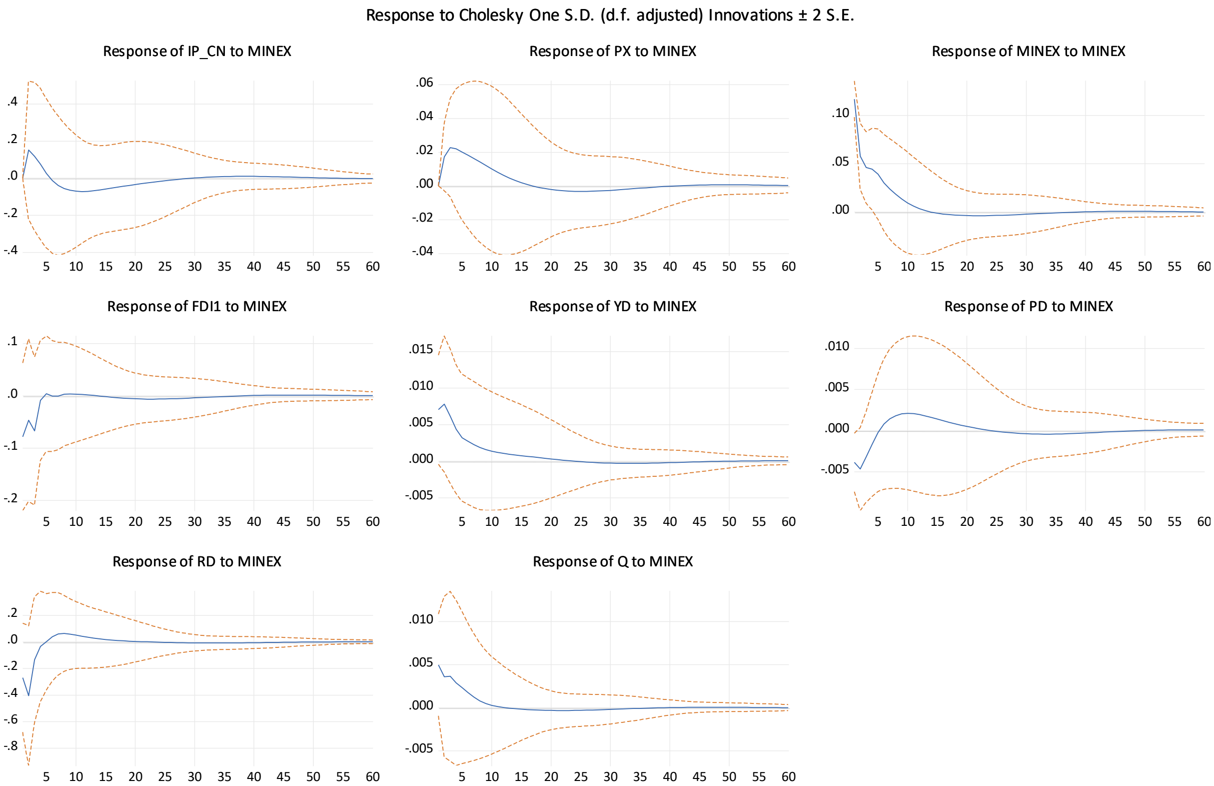
8.1.1 Impulse response functions of Chinese industrial production



8.1.2 Impulse response functions of the export price index

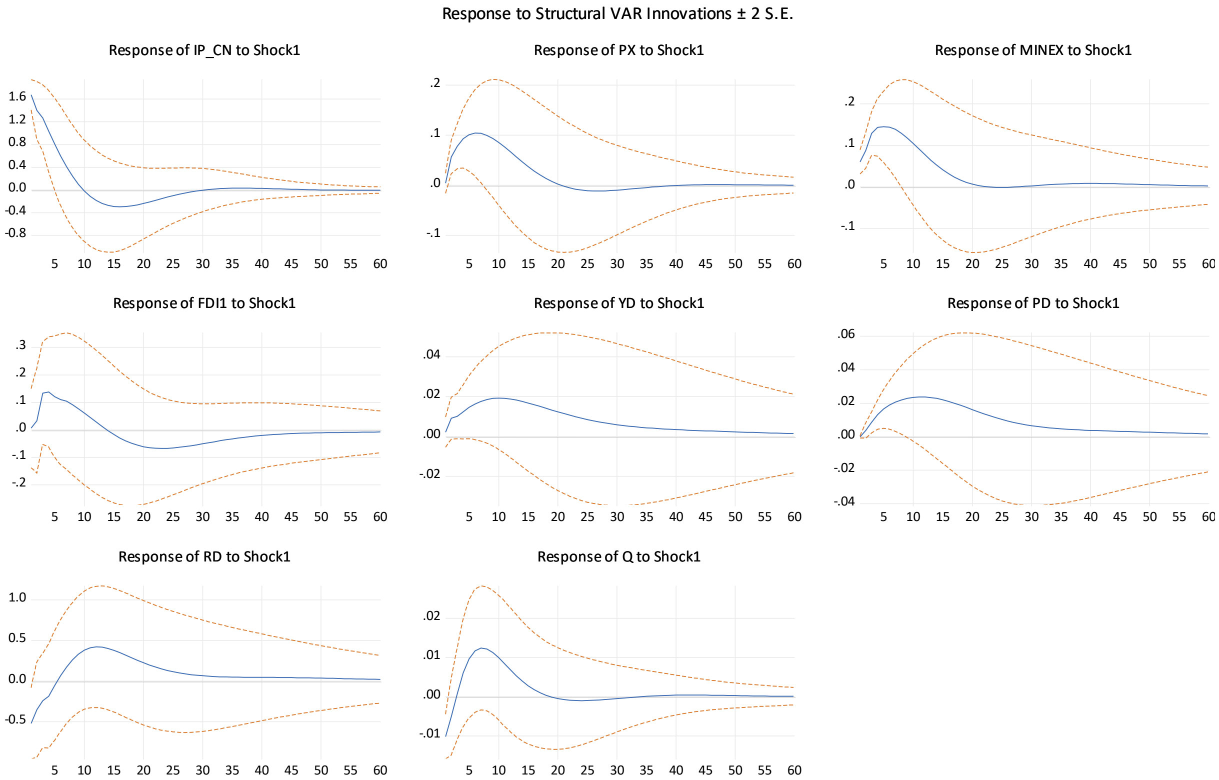


8.1.3 Impulse response functions of the mining export

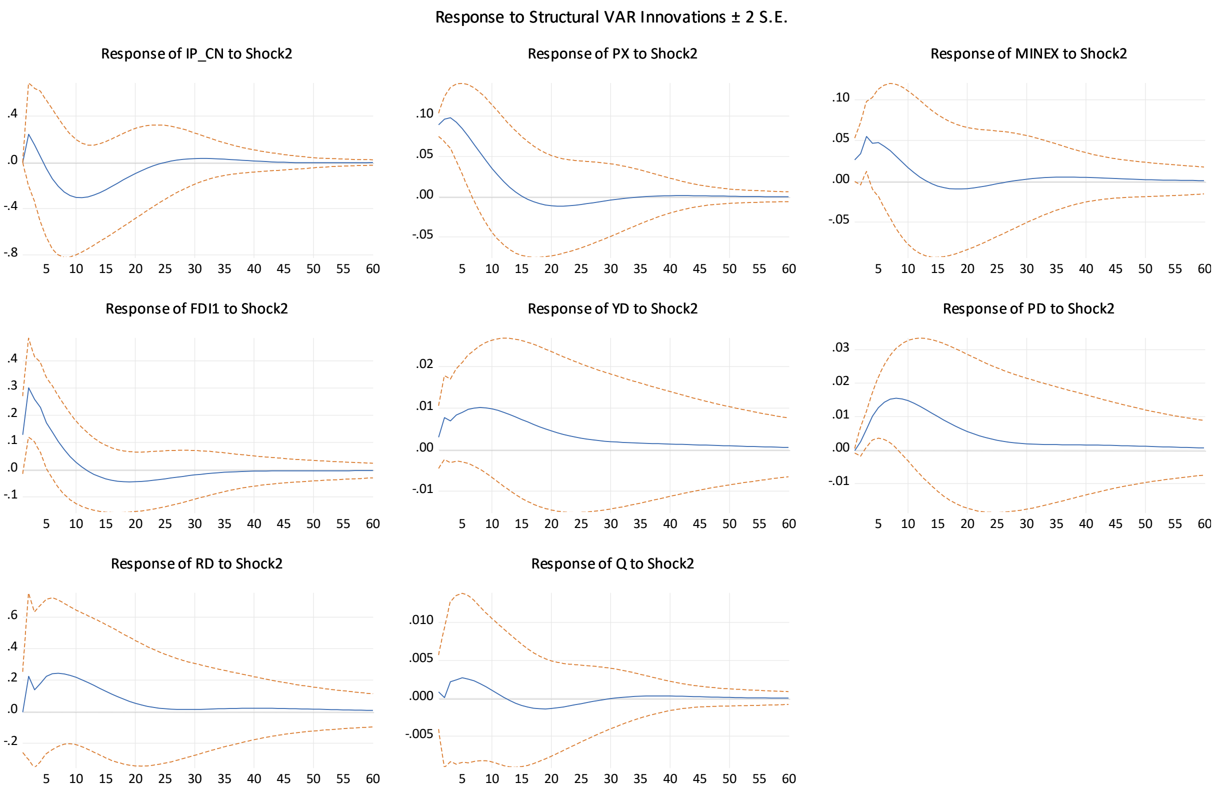


.2 Non-recursive VAR model

8.2.1 Impulse response functions of Chinese industrial production



8.2.2 Impulse response functions of the export price index



8.2.3 Impulse response functions of the mining export